

NAME P/N QTY	CRIT	FAILURE MODE & CAUSES	FAILURE EFFECT	RATIONALE FOR ACCEPTANCE
LOWER ARM AND BLADDER ITEM 103 (1) LEFT (1) RIGHT ----- 0103-810151-02 0103-810151-03 (2)	2/1RB	103FM16 Loss of fabric restraint. Separation of seam or hole in fabric. Defective thread, restraint material.	END ITEM: Opening in fabric restraint bladder. Loss of restraint circumferential load carrying capability. GFE INTERFACE: Loading and abrading of bladder. MISSION: None. CREW/VEHICLE: None with single failure. Loss of crewman with loss of bladder. TIME TO EFFECT /ACTIONS: Minutes. TIME AVAILABLE: Days. TIME REQUIRED: Days. REDUNDANCY SCREENS: A-PASS B-FAIL C-PASS	A. Design - The lower arm restraints are fabricated from 6.4 ounce dacron fabric which exhibits a minimum tensile strength of 300 lbs. (warp) and 250 lbs (fill). At 4.4 psid (normal operating pressure) the hoop load is 12.6 lbs/in giving the restraint fabric an ultimate safety factor of 23.8 for warp and 19.7 for fill. At 5.5 psid (max operating pressure) the restraint fabric provides ultimate safety factors of 19.1 for warp and 15.9 for fill. At 8.8 psid (max BTA operating pressure) the restraint fabric provides ultimate safety factors of 11.9 for warp and 9.9 for fill. S/AD minimum safety factors for softgoods at 4.4 psid is 2.0 for ultimate. At both 5.5 psid and 8.8 psid the S/AD minimum safety factors for softgoods is 1.5 for ultimate. The basic seam employed in the construction of the arm restraints is a double row of top stitching over a single row of joint stitching. Structural testing has determined that seam strength is equal to or better than the strength of the restraint material. The lower arm bladder assembly is formed from a series of patterned pieces of urethane coated nylon oxford fabric, seamed together by dielectric heat, to which flanges are also heat sealed. The bladder seams and flanges are reinforced by heat sealed overtaping to enhance structural integrity. The solution coated bladder is protected internally in known areas of high wear by an additional heat sealed abrasion layer. There are two types of bladder fabric. One is constructed of a base nylon fabric with a solution coated urethane. The other is constructed of the same nylon with a urethane laminate coating. The following paragraph applies to the solution coated nylon. Testing has shown that the bladder fabric minimum tensile strength is 105 lbs/inch (fill) and 140 lbs/inch (warp). The tearing strength is 3.5 lbs/inch in fill and 6.0 lbs/inch in warp. Nominally, hoop load is absorbed by the bias direction of the bladder fabric. However, the safety factors are based on the fabric yarns (fill yarns) which have the least strength. Based on a predicted hoop load of 12.6 lbs/inch, the minimum safety factor for hoop stress is 8.3 against a S/AD design minimum ultimate safety factor of 2.0 at 4.4 psid (normal operating pressure). At 5.5 psid (max failure pressure) and at 8.8 psid (max VTA operating pressure), the fabric ultimate safety factors are 6.6 and 4.2 against hoop loads of 15.7 and 25.2 lbs, respectively. The S/AD required minimum ultimate safety factor at 5.5 and 8.8 psid is 1.5. Testing has demonstrated that the breaking strength of the bladder seams meets or exceed that of the bladder fabric. The following paragraph applies to the laminate coated nylon. Testing has shown that the bladder fabric minimum tensile strength is 180 lbs/inch in the warp direction and 170 lbs/inch in the fill direction. The tearing strength is 3.5 lbs/inch minimum in both directions. Nominally, hoop load is absorbed by the bias direction of the bladder fabric. The minimum strength value, 170 lbs/inch is therefore used for determining safety factors. Based on a predicted hoop load of 12.6 lbs/inch, the minimum safety factor for hoop stress is 13.5 against a S/AD design minimum ultimate safety factor of 2.0 at 4.4 psid (normal operating pressure). At 5.5 psid (max failure pressure) and at 8.8 psid (max BTA operating pressure), the fabric ultimate safety factors are 10.8 and 6.7 against hoop loads of 15.7 and 25.2 lbs, respectively. The S/AD required

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minimum ultimate safety factor at 5.5 and 8.8 psid is 1.5. Testing has demonstrated that the breaking strength of the bladder seams meets or exceeds that of the bladder fabric.

B. Test -

Acceptance:

Component - see inspection for acceptance.

PDA:

The following test is conducted at the arm assembly level in accordance with ILC Document 0111-710112:

Visual examination for structural damage following a proof pressure test at 8.0 + 0.2 - 0.0 psig for a minimum of 5 minutes conducted with the TMG removed.

Certification:

The lower arm restraint assembly was successfully tested (manned) during SSA certification testing to duplicate 458 hours operational life (Ref. ILC Report 0111-711330). The following usage, reflecting requirements of significance to the lower arm restraint assembly, was documented during certification:

Requirement	S/AD	Actual
Shoulder Rotations	29348	60000
Elbow Flex/Ext	49660	102000
Don/Doff Cycles	98	400
Pressure Hours	458	916

The lower arm restraint assembly was successfully subjected to an ultimate pressure of 13.2 psid during SSA certification testing (Ref. ILC Report 0111-711330). This is 1.5 times maximum BTA operating pressure based on 8.8 psid.

C. Inspection -

Components and material manufactured to ILC requirements at an approved supplier are documented from procurement through shipping by the supplier. ILC incoming receiving inspection verifies that the materials received are as identified in the procurement documents, that no damage has occurred during shipment and that supplier certifications have been received which provide traceability information.

MIP's are performed for inspection of sewn seams during the arm restraint manufacturing process to assure that this particular failure cause is precluded from the fabricated item.

During PDA the following inspection points are performed at the arm assembly level in accordance with ILC Document 0111-710112:

1. Inspection for fabric or material degradation. Inspection of seams for broken or frayed stitches.
2. Visual inspection for structural damage following proof pressure test conducted with TMG removed.

D. Failure History -

None.

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		103FM16		<p>E. Ground Turnaround - None for every component within its limited life requirements.</p> <p>Additionally, every 4 years or 229 hours of manned pressurized time, the arm restraint and bladder assemblies are removed from the arm assembly and subjected to a complete visual inspection (interior and exterior surfaces) for material damage and degradation.</p> <p>F. Operational Use - Crew Response - Pre EVA: No response, single failure undetectable by crew. Continue EVA prep. EVA: No response, single failure undetectable by crew. Continue EVA. Training - No training specifically covers this failure mode. Operational Consideration - Not applicable.</p>

EXTRAVEHICULAR MOBILITY UNIT
SYSTEMS SAFETY REVIEW PANEL REVIEW
FOR THE
I-103 ARM ASSEMBLY
CRITICAL ITEM LIST (CIL)

EMU CONTRACT NO. NAS 9-97150

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